from the target object. The ultrasound image forming unit **110** may be further configured to form a three-dimensional ultrasound image of the target object based on the received ultrasound echo signals.

[0018] FIG. **2** is a block diagram showing an illustrative embodiment of an ultrasound image forming unit **110**. The ultrasound image forming unit **110** may include a transmit (Tx) signal generating section **111**, an ultrasound probe **112** including a plurality of transducer elements (not shown), a beam former **113**, an ultrasound data forming section **114** and an image forming section **115**.

[0019] The Tx signal generating section **111** may generate Tx signals according to an image mode set in the ultrasound system **100**. The image mode may include a brightness (B) mode, a Doppler (D) mode, a color flow mode, etc. In one exemplary embodiment, the B mode may be set in the ultrasound system **100** to obtain a B mode ultrasound image.

[0020] The ultrasound probe **112** may receive the Tx signals from the Tx signal generating section **111** and generate ultrasound signals, which may travel into the target object. The ultrasound probe **112** may further receive ultrasound echo signals reflected from the target object and convert them into electrical receive signals. In such a case, the electrical receive signals may be analog signals. The ultrasound probe **112** may be a three-dimensional probe, a two-dimensional probe, a one-dimensional probe or the like.

[0021] FIG. **3** is an illustrative embodiment of an ultrasound probe **112**. At least one transducer element (not shown) of the ultrasound probe **112** generates an image plane IP, which is used to scan a region of interest ROI. The image plane IP may be one of slice planes of the three-dimensional ultrasound image. The sensor **120** is attached to the housing of the ultrasound probe **112** to determine the position and orientation of the image plane IP. The ultrasound system **100** coupled with the ultrasound probe **112** via the probe cable **105** can use the data generated by the sensor **120** to determine the position and orientation of the sensor **120** and/or the image plane IP, as described below.

[0022] In this preferred embodiment, the sensor **120** is a magnetic sensor that monitors the free-hand movement of the ultrasound probe **112** in six degrees of freedom with respect to a transducer element **170**. As shown in FIG. **3**, the sensor **120** and the transducer element **170** each define an origin (**122**, **172**, respectively) defined by three orthogonal axes (X', Y', Z' and X", Y", Z", respectively). The sensor **120** monitors the translation of the origin 122 with respect to the origin **172** of the transducer element **170** to determine position and monitor the rotation of the X', Y', Z' axes with respect to the X", Y", Z" axes of the transducer element **170** to determine orientation.

[0023] The position and orientation of the sensor **120** can be used to determine the position and orientation of the image plane IP. As shown in FIG. **3**, the image plane IP defines an origin OR defined by three orthogonal axes X, Y, Z, which are preferably aligned with the origin of a center acoustic line generated by the ultrasound probe **112**. The position of the origin **122** and the orientation of axes X', Y', Z' of the sensor **120** may not precisely coincide with the position of the origin OR and the orientation of the axes X, Y, Z of the image plane IP. For example, in FIG. **3**, the origin OR of the image plane IP is offset from the origin **122** of the sensor **120** by a distance z_0 along the Z-direction and a distance of y_0 along the Y-direction. In FIG. **3**, there is no offset along the X-direction nor is there a rotational offset in the orientation of the axes. Accordingly, the position and orientation of the sensor **120** do not directly describe the position and orientation of the image plane IP.

[0024] To determine the position an orientation of the image plane IP from the position and orientation of the sensor **120**, sensor calibration data is used to transform the position and orientation of the sensor **120** to the position and orientation of the image plane IP. For simplicity, the term “position and orientation” is used to broadly refer to position and/or orientation. Accordingly, if the sensor **120** has the same orientation as the image plane IP, then the position and orientation calibration data may not contain any orientation calibration data. Similarly, as shown in FIG. **3**, the sensor **120** may not have a positional offset with respect to one or more axes of the image plane IP.

[0025] There are a number of ways of defining the image plane/sensor offset. One method of calibrating at least some types of sensors use three orthogonal linear dimension offsets in X, Y, Z and three rotation angles about each of these axes. Other methods include using a position transformation matrix or quaternions, which are described in the user manual for the mini Bird™ and the Flock of Bird™ systems by Ascension Technology Corp.

[0026] As described above, the ultrasound probes with position and orientation sensors are typically used only with ultrasound systems that contain the calibration data for the probe/sensor pair. Conventionally, the probe/sensor pair is calibrated, and the calibration data is stored in the ultrasound system **100**, which will be used in conjunction with the probe/sensor pair. If the probe/sensor pair is to be used with a different ultrasound system, then the probe/sensor pair typically needs to be re-calibrated on that different ultrasound system. Since sonographers are often unable or unwilling to perform probe/sensor pair calibration, probe/sensor pairs are often used only with the ultrasound system for which the probe/sensor pair was initially calibrated.

[0027] Referring back to FIG. **2**, the beam former **113** may convert the electrical receive signals outputted from the ultrasound probe **112** into digital signals. The beam former **113** may further apply delays to the digital signals in consideration of the distances between the transducer elements and focal points to thereby output receive-focused signals.

[0028] The ultrasound data forming section **114** may form a plurality of ultrasound data by using the receive-focused signals. In one embodiment, the plurality of ultrasound data may be radio frequency (RF) data or IQ data. The image forming section **115** may form the three-dimensional ultrasound image of the target object based on the ultrasound data.

[0029] Referring back to FIG. **1**, the sensor **120** may be mounted on one side of the ultrasound probe **112**. In one embodiment, by way of non-limiting examples, the sensor **120** may be built in the ultrasound probe **112** to be away from the plurality of transducer elements (not shown) by a predetermined distance. Alternatively, the sensor **120** may be externally mounted on the ultrasound probe **112** to be away from the plurality of transducer elements. The sensor **120** may include three-dimensional sensor, which can detect a three-dimensional position and an angle of the ultrasound probe **112**.

[0030] The memory **130** may store a three-dimensional CT image of the target object. In one embodiment, by way of non-limiting examples, the three-dimensional CT image